From skin to brain

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DOI:
10.33612/diss.123420732

Positions accompanying the doctoral thesis titled:
From Skin to Brain
Modelling a whole-body coordination scenario of nervous system origin

1. An explanatory gap exists in the evolutionary background of nervous systems; some animal groups have no neurons at all while others have neurons exhibiting all three essential neuronal characteristics: electrical excitability, elongations, and synapses. (Chapter 1)

2. Calcott's concept of a *lineage explanation*—a progression of evolutionary stages satisfying a *continuity* as well as a *production* requirement—provides a useful framework for investigating this explanatory gap. (Chapter 1)

3. There are broadly two ways of looking at the production requirement for nervous system evolution, the way in which early nervous systems were useful to their possessors: as an *input-output* (IO) system, emphasizing the reactive role of individual cells; or as an *internal coordination* (IC) system, emphasizing active, whole body-level neural organization. (Chapter 1)

4. The relatively underexposed IC-view can explain how early nervous systems could have dealt with whole, soft bodies composed of cells with limited developmental diversification. (Chapter 1)

5. The animals in which nervous systems first arose were likely soft-bodied, small, and exhibited limited developmental diversification yet possessed epithelia, electrical excitability, the ability to form elongations, and the molecular building blocks for synapses. (Chapter 2)

6. The functional value of the early nervous system likely lay in relatively fast and coordinated macroscopic movement and the ability to utilize a gut while energetic demands likely caused a significant constraint. (Chapter 2)

7. Given a worm-like body shape of limited size, primitive synaptic or juxtacrine signalling, and electrical excitability, the resulting epithelial excitability provides whole-body coordination. (Chapter 3)

8. The addition of elongations to this system enables the coordination to be scaled and to be effective in a much wider range of body sizes. (Chapter 4)

9. The addition of elongation also allows the coordinative benefit for the entire system to be achieved with a smaller proportion of cells with energetically expensive coordinative functionality. (Chapter 5)

10. The system with the best balance between coordination and energetic efficiency—a sparse network of connected cells on the surface of the animal—strongly resembles a nerve net, a plausible candidate for the earliest nervous system. (Chapter 5)

11. This computational model demonstrates how an internal coordination-driven scenario of early nervous system evolution satisfies the requirements of the lineage explanation within the given empirical constraints.

12. With this demonstration, the salience of the IC-view is stressed, leading to better understanding of early nervous system evolution.